NWS Operations Proving Ground

Final Report

Testing the Use of Cloud AWIPS by NWS Incident Meteorologists

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1. Executive Summary

During the period of mid-July through September of 2021, the Operations Proving Ground (OPG), in conjunction with the Fire Weather program of the Analyze, Forecast and Support (AFS) portfolio, conducted a test of the use of AWIPS in the Cloud (a.k.a. Cloud AWIPS) by NWS Incident Meteorologists (IMETs) who were deployed on active wildfires in the western CONUS. The primary goals of this test were to evaluate the usability of Cloud AWIPS by IMETs who may be deployed in areas with sub-optimal network conditions, gathering information related to the cost factors of running Cloud AWIPS and learning about the level of support needed to operate the system to meet the news of deployed IMETs. All of the lessons learned from this test can be used to inform both AFS and the Office of Central Processing (CP) portfolios with regard to future requirements development for a more fully operational Cloud AWIPS system supporting IMET deployments.

Overall, the test was highly successful, with the vast majority of the IMETs reflecting very positively on the experience via a survey that was sent to each one following their deployment. The forecasters found the system to be fast and reliable, even under some difficult network conditions. There were numerous lessons learned from this experiment, which will be detailed in this report. The cost analysis of this test, while not painting a complete picture of cost for a more fully operational Cloud AWIPS system, does provide a key starting point for making a final cost determination.

2. Background

Since the advent of the AWIPS-2 system, IMETs and other remote NWS deployments have made use of a "Thin Client" application to access meteorological data from AWIPS. The Thin Client is a version of the Common AWIPS Visualization Environment (CAVE) software with some capabilities, such as the Graphical Forecast Editor (GFE), removed or disabled. CAVE, and by extension the Thin Client, operate by downloading full datasets (e.g. satellite and gridded model data) from an AWIPS server and rendering that data into screen images **on the client itself**. The Thin Client accesses an AWIPS server through a proxy system running at any of the NWS Regional Headquarters. This proxy system enables the use of compression to make downloading the data on lower-bandwidth connections faster, but with the emergence of higher resolution datasets, like GOES-R satellite imagery and Multi-Radar, Multi-Sensor (MRMS) grids, the amount of data to be downloaded by Thin Client has become overwhelming. At times, this volume of data to be downloaded can render Thin Client impractical to use.

Over a period of roughly two-and-a-half months, over 60 IMETs tested Cloud AWIPS in the field (starting July 19th, 2021). The OPG set up two “disposable” cloud Instances under our existing Cloud AWIPS contract. These instances provide access for up to 20 users at one time. The Cloud AWIPS system works by running the CAVE application on the cloud system itself, on the same network as the AWIPS servers that are hosting the CAVE connections. These network connections are very fast, which alleviates the impact of downloading large amounts of data. The remote forecasters then interact with the CAVE application via a remote desktop connection. This remote desktop system employs a highly agile, compressed video stream that greatly compensates for a poor network connection.

3. Technical Details

The OPG's Cloud AWIPS system is hosted in the Amazon Web Services (AWS) Elastic Cloud Computing (EC2) environment. The system consists of a mix of "Reserved" instances, those that run 24x7 and are paid for up-front at a significant cost saving, and "On-Demand" instances, which are paid for by the hour and only run when needed. The table below shows the number and types of instances used on the OPG Cloud AWIPS.

EC2 Instance Type[1]	Quantity	Purpose	Reserved or On-Demand
R5a.large	1	Unidata LDM	Reserved
M5.4xlarge	1	AWIPS Server	Reserved
G3.4xlarge	1	Admin, Dev. & Case Review	On-Demand
G4dn.8xlarge	2	CAVE	On-Demand

The "Unidata LDM" instance is running Unidata's Local Data Manager (LDM) software, and receives data from Unidata's Internet Data Distribution system (IDD) and the NWS Central Region Headquarters (CRH). The IDD is composed of all data available on NOAAPORT and CONDUIT, Level-II data from all WSR-88Ds, a complete feed of Multi-Radar, Multi-Sensor grids and more. The connection to CRH is to acquire gridded Geostationary Lightning Mapper (GLM) data.

The "AWIPS Server" instance is running all of the backend processes required for AWIPS including: EDEX, the PostgreSQL database, QPID and PyPies. This instance is also capable of running up to six Open Radar Product Generator (ORPG) instances, however, these were not used during the IMET test.

The G3.4xlarge instance has multiple uses. The OPG staff routinely use this machine as an access point to our cloud space to perform administrative duties on all of the other instances. It has both AWIPS server and CAVE software installed, making it a "standalone" AWIPS system. In this capacity, it is valuable for reviewing archived weather cases and for generating graphics to be used in training or other presentations. This system is also used for code development.

The two G4dn.8xlarge instances are where experiment participants, like the IMETs, normally login to run CAVE and access data. These instances have a significant amount of memory and video card capacity, allowing them to accommodate as many as ten simultaneous users, assuming each user runs one CAVE session.

[1] AWS reference on EC2 instance types

4. Cost

Estimating the potential cost for a future operational Cloud AWIPS system is non-trivial, but the OPG can provide useful information based on our current system design. It is important to note that the OPG Cloud AWIPS system was not designed with the intention of supporting multiple users for prolonged periods. We believe a different configuration could yield an increase in user capacity without necessarily increasing cost. Further, by making greater use of "Reserved" instances, additional savings can be realized.

The OPG estimates that the systems used in our experiment to provide access to IMETs for a full year could be acquired for approximately $50,000. **This estimate comes with some significant caveats, however.** First, this would only cover the cost of a single set of systems at a single AWS facility (e.g. N. Virginia). Therefore, there would be no geographic diversity or redundancy in the system, which are both likely requirements for a more operational system. Also, this estimate does not include any dedicated support for the IMETs using the system. During the OPG experiment, nearly all support was provided by the OPG SOO. Since the OPG can not incur premium pay, support was limited to 8x5 and no holidays. It is beyond the scope of this report to suggest how full-time support might be provided.

Finding #1: The relatively low cost of the OPG's experiment strongly indicates the potential for a more fully operational system to be acquired for a reasonable expenditure.

5. User Experience

The OPG sent a survey to every IMET following their deployment, querying such things as what type of facility in which they were deployed, type of Internet connection, monitor size and resolution, and most importantly, how they felt about the performance of the system. The survey contained only free-form answers, so providing objective, statistical information from it would be difficult. This section will summarize the overall nature of the feedback. The raw answers to the survey are available, if needed.

The forecasters were deployed to more than 20 different wildfire locations, and the type of facility in which they were deployed varied from schools and defunct shopping centers to tents. Unsurprisingly, those deployed in more permanent facilities tended to have better and faster Internet connectivity, while those in more primitive conditions were often relying on a cell phone hotspot or a satellite-based connection. Also as expected, those that had more stable and faster Internet connections reported the best overall user experience. While we did not ask participants for the specific speed of their connection (which can be difficult to determine objectively), informal discussions with the forecasters indicated that Cloud AWIPS could still be usable at speeds as low as 2 megabits per second (Mbps). It is important to note, however, that there are a number of variables that contribute to the speed and responsiveness of the system. Notably, the size and resolution of the computer's monitor plays an important role. A larger monitor, with higher screen resolution, will require more pixels to be streamed, and thus will have higher bandwidth demands. It was also noted that the latency of the connection (the number of milliseconds required for data packets to travel the full connection) appeared to play a role. While diagnosing some poor performance being experienced by one of the IMETs, we made deeper inquiries about their

Internet connection type. It was learned that on this particular deployment, the IMET was using a shared WiFi connection to a satellite-based Internet provider. The available bandwidth was not very high (about 2 Mbps maximum), but due to the fact that they were using the satellite connection, latency was very high. It was determined that the combination of relatively low bandwidth and high latency was the cause of the poor performance. This was supported by the fact that the other IMETs at the time were not experiencing any issues.

As was stated earlier, the feedback from the IMETs about the performance of Cloud AWIPS was overwhelmingly positive. There were 28 total survey responses. When asked to describe the overall user experience, 23 of the respondents made some form of positive feedback. The following is a small sample of the responses to that question.

> *"Speed was fantastic, making navigating the menus relatively seamless, particularly in comparison to Thin Client."*

> *"I am by no means a power user...but I thought that it was overall a big improvement from [Thin Client]."*

> *"It was fast loading procedures and I never found anything that bogged it down too much."*

The IMETs were asked to list what they liked best about using Cloud AWIPS. 14 of the 28 responses specifically mentioned "speed" or "responsiveness" in their response. Again, we offer a sample of survey responses.

> *"It was simple to use, reliable, fast, kept my session (procedures, images) going all through my incident without having to reload everything each morning."*

> *"Huge upgrade from Thin Client. Allowed quick/efficient model analysis (models in plan view, forecast soundings, etc.), satellite viewing (helpful for fire intensity and smoke monitoring), radar monitoring (including using things like the "Time of Arrival" tool), and MRMS viewing (good where there is poor radar coverage like where I was located in central ID)."*

> *"The speed was nearly as good as being in an office."*

There were, of course, some issues reported. We asked the participants to describe what they liked least about Cloud AWIPS. A solid plurality of the responses (12 out of 28) mentioned frequently being disconnected from their session. The OPG worked with Jason Burks from the MDL cloud team to try and determine the root cause of these frequent disconnects. We worked to adjust settings in the cloud environment related to screen saver timeout and other parameters linked to inactivity, but we were never able to conclusively determine the cause or if our changes improved the situation significantly.

There were also problems encountered related to the size of monitors being used. The CAVE interface and dialog windows were all designed for the baseline AWIPS system, which has 27-inch, 2560x1440 pixel monitors. Some windows, notably the Import GIS Data window, are too large vertically to display correctly on any monitor smaller than about 1080 pixels in height. It has been noted in previous OPG experiments using Cloud AWIPS that the main Warngen dialog also suffers from this issue. It was speculated that this could be corrected by simply putting the contents of these windows into a scrolled window, so that all of the window content can be reached on a smaller screen. This change would require a Java code modification within CAVE.

Finally, there was an issue which has been brought up frequently in other experiments, and was discussed with the IMETs in chat. That is the inability to access D2D procedures and color tables from the forecaster's home AWIPS. The following is a sample of responses received about what the IMETs like least about Cloud AWIPS.

> *"The vertical display resolution issues. [Cloud AWIPS] is too squished to be used on the built in laptop monitors. Also the import GIS data dialog was completely unusable unless working on at least a 1080p display and then only while in full screen mode."*
>
> *"Frequent disconnects every few minutes, which made it taxing/time-consuming to log in again each time."*
>
> *"Spending time rebuilding color curves from scratch. There was a trick in getting certain GUIs to work properly. You had to have the correct resolution and go full screen."*

Finding #2: Subjectively, Cloud AWIPS performs significantly better than Thin Client, especially under trying network conditions.

Finding #3: Some CAVE dialogs that are critical to IMET use are unusable on monitors smaller than about 1080 pixels in height.

Finding #4: The availability of D2D procedures and color maps from a forecaster's home AWIPS would be extremely beneficial not only to IMET use of Cloud AWIPS, but also to any testbed or proving ground experiment where Cloud AWIPS is featured.

6. Findings and Recommendations

The following is a summary of all findings and subsequent recommendations. The OPG would like to make clear that it is not our intention to try and direct either CP or the AWIPS Program on how to proceed with a more operational version of Cloud AWIPS, but rather we hope the information presented here can be used to guide future decisions on the direction of this effort.

Finding #1: The relatively low cost of the OPG's experiment strongly indicates the potential for a more fully operational system to be acquired for a reasonable expenditure.

Recommendation #1: The OPG, in discussion with the AWIPS Program, has learned that they have a FY22 milestone to acquire cloud resources for a more operational Cloud AWIPS system for IMET use during the CY22 fire season. The OPG fully supports this effort, and is willing to cooperate in any capacity needed.

Finding #2: Subjectively, Cloud AWIPS performs significantly better than Thin Client, especially under trying network conditions.

Recommendation #2: The OPG believes that Cloud AWIPS should be investigated as a viable alternative to Thin Client, not just for IMET use, but also other IDSS deployment situations. The cost of acquiring the necessary cloud systems could be partially offset by the retirement of Thin Client (e.g. laptops that can successfully run Cloud AWIPS would be cheaper than those needed to run Thin Client)

Finding #3: Some CAVE dialogs that are critical to IMET use are unusable on monitors smaller than about 1080 pixels in height.

Recommendation #3: The OPG suggests that the feasibility of altering the dialog windows mentioned in this report be investigated. It is understood that Java code changes within CAVE can be non-trivial, and it is possible that this sort of modification can not be made in a reasonable amount of time.

Finding #4: The availability of D2D procedures and color maps from a forecaster's home AWIPS would be extremely beneficial not only to IMET use of Cloud AWIPS, but also to any testbed or proving ground experiment where Cloud AWIPS is featured.

Recommendation #4: In conversations with the AWIPS Program, the OPG has learned of an effort to make the configuration files related to the Hazard Services component of AWIPS available in some sort of sharing repository, perhaps on VLab. We **strongly** advocate for this effort to be expanded to all configuration files, such that user D2D procedures and color tables would also be available.